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Astigmatic correction: A clinical comparison of two types of hydrophilic toric lenses

Katherine A. Hinshaw
Pacific University

Mark A. Michael
Pacific University

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Abstract

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ASTIGMATIC CORRECTION:

A CLINICAL COMPARISON OF TWO TYPES OF HYDROPHILIC TORIC LENSES

PACIFIC UNIVERSITY
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KATHERINE A. HINSHAW
MARK A. MICHAEL
D.C. WEST, ADVISOR

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MARK A. MICHAEL

D. C. WEST, O.D., ADVISOR

GRADE_____

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ABSTRACT

Two brands of soft toric lenses utilizing similar designs were studied. Each lens type was compared as to (1) its success in correcting the refractive astigmatism, (2) accuracy in the manufacture of the parameters ordered and time required for the delivery of those orders, and (3) the "appropriateness" of the lens when ordered according to the fitting guide's instructions.

At first glance, the Hydro-Marc™ lens appeared to be better suited to most patients' needs when considering the range of parameters available. However, due to problems encountered in delivery time, reliability in the fabrication of the lens, and variability in fit between ordered lenses and those used in diagnostic fitting, the chances for achieving successful fits do not appear good at this time.

Given that the patient approximated those parameters available, the Hydrocurve II™ toric lens was found to have a high level of success.

INTRODUCTION

It has been estimated that between 25 and 32% of the general population has significant (that is, greater than .75 Diopter) astigmatism.[7] In the past, if astigmatic patients wanted contact lenses and were unable to wear hard lenses, spherical softs were fit. Spectacles incorporating the astigmatic correction to wear over the soft lenses were then prescribed when critical vision was needed.[5] Claims that thicker soft lenses correct greater percentages of astigmatism are "wishful thinking", and sustained vision with these lenses is usually much lower than that recorded.[2] The desirability of a soft contact lens which will correct not only a spherical refractive error but also astigmatism is obvious in light of these facts.

Performance problems with previous toric soft lenses include variable visual acuities and discomfort with prolonged near use (both probably due to rotation), and reduced daily wearing time with lens sensation at the lower limbal area (probably due to lens characteristics designed to reduce rotation).

Tightness of fitting and centration both appear to be important factors in reducing rotation of the lens. Ill-fitting lenses will not be free to rotate in the same way as optimum-fitting lenses.[6]

Fitting success of toric soft lenses will depend on arriving at and maintaining the correct cylinder axis position. Extra care must be exercised in obtaining an optimum fit, as

well, to avoid physiological problems. Therefore, good centration with an appropriate lens-cornea relationship, giving adequate vertical translation during the blink, is thus imperative.

Some studies have found that after a several-hour wearing period, the base-apex line of prism ballasted lenses changes from the initial position.[4] The action of the lids also significantly affects lens rotation,[1,3,4,6] as does the looseness of the bulbar conjunctiva.[6,7] These must be evaluated for each patient, accordingly.

Thin, mobile (i.e., optimum-fitting) lenses seem to be better to fit in toric designs than thick, tight ones, because there is less "locking-in" of lens position, which allows the lens design features to locate and stabilize the cylinder axis.

At the time this study was begun, three hydrogel lenses were approved for use in the U.S.: Durasoft-TT™, Hydro-Marc™, and Hydrocurve II™.

The purpose of this research was to compare, if possible, and evaluate two of these toric soft lenses, the Hydrocurve II and the Hydro-Marc. Both are back-surface toric, lathe-cut lenses, using prism ballast to stabilize the cylinder axis. Table I shows the characteristics and available parameters of each lens at the start of the study (Feb., 1979; Hydrocurve II is now available in more powers and axes.).

We proposed to fit a number of patients with either a Hydro-Marc or a Hydrocurve II lens, according to the respective fitting guides published by the manufacturers. Because of the limited

TABLE I
AVAILABLE PARAMETERS

Hydro-Marc Toric™

% water	Power Range	Diameters	Base Curves	Prism
43	± 20.00 D. Sphere to -6.00 D. Cyl., of any axis	14.0 or 14.5 mm	8.45 to 9.20 in 0.15 mm steps*	1½ prism diopter (slab-off form)

Hydrocurve II™ Toric**

46	-1.50 to -6.00 D. Sphere -1.25 D. Cylinder, axis 90 or 180, ± 20 degrees, in 5 degree steps	13.5 mm only	8.60 mm only	1 prism diopter (peri-ballast)

*Base Curve = average of toric back surface curvatures
**those parameters available at start of study (Feb., 1979)

parameters available in the Hydrocurve II, it was arbitrarily decided that any patient with a refractive error and cornea such that a HC II could reasonably be used, would be fit with one. other patients whose corneas and/or refractive errors were not suitable for the HC II were fit with a Hydro-Marc lens.

Several characteristics and factors of these lenses were observed, including (1) correction of the astigmatism as measured by visual acuity, (2) accuracy in the production of the lenses as to sphere and cylinder power, cylinder axis, and the speed with which the lab provides the finished product, and (3) "appropriateness" of lenses when ordered according to the fitting guide's instructions.

Attempts were made to verify power, axis, and base curves of both sets of diagnostic lenses used to fit patients in this study. Further discussion on the accuracy and reliability of base curve verification of toric soft lenses will be presented later.

PROCEDURE

PATIENT SELECTION

Patients were screened for appropriate characteristics before participating in the study. They were considered to have at least one "normal" eye; that is, one which (1) is correctable to at least 20/30 with spectacles, (2) shows no evidence of ocular or adnexia abnormalities or infections, (3) shows no tear insufficiency and has a normal tear break-up time, and (4) a clear cornea with no apparent contraindications for normal

soft lens wear.

No patient had any ocular disease, or used any ocular medication during the study.

In addition, each patient manifested residual astigmatism of 0.75 Diopter or more with spherical soft lenses, or visual acuity with spherical soft lenses of 20/30 or worse, and/or reduced visual acuity with spherical soft lenses of at least two lines when compared to visual acuity with spectacles.

There was no requirement as to patient age, sex, occupation, or reason for desiring contact lenses. Previous contact lens wearers were accepted into the study, provided that they met the described criteria at the beginning of the investigation.

Patients involved with the study were recruited from the student population at Pacific University and the general public. All the potential candidates for the study were required to have a routine analytical examination done through the general clinic of Pacific University's College of Optometry, and were further screened by the investigators after this examination. Only those meeting the prescribed qualifications were used and counted in the study. If any contraindications for soft lens wear existed or surfaced, the patient was discontinued. Data from a total of 24 eyes was gathered and summarized; see Table II for patient profile information.

FITTING

Lenses were fit according to each manufacturer's respective

TABLE II
PATIENT PROFILE

PATIENT	HYDRO-MARC TORIC		HYDROCURVE II TORIC	
Age, in years				
range	23 to 38		22 to 41	
mean	29.0		30.25	
S.D.	±5.98 yrs.		±8.26 yrs.	
Sex				
male	6		3	
female	3		1	
Keratometry (Low K)				
range	40.12 to 43.87 D.		42.75 to 44.62 D.	
mean	42.12 D. (8.01 mm)		43.58 D. (7.76 mm)	
S.D.	±1.14 D.		±0.62 D.	
Corneal Cyl.				
range	1.12 to 5.63 D.		0.62 to 2.75 D.	
mean	2.62 D.		2.08 D.	
S.D.	±1.33 D.		±0.73 D.	
Refractive Sphere	Hyperopia	Myopia	Hyperopia	Myopia
range	+0.25 to +5.00 D.	-2.00 to -4.75 D.	N/A	-1.75 to -4.75 D.
mean	+1.97 D.	-3.00 D.	N/A	-3.04 D.
S.D.	±2.01 D.	±1.24 D.	N/A	±0.93 D.
Refractive Cyl.				
range	-1.25 to -6.00 D.		-0.75 to -1.50 D.	
mean	-2.82 D.		-1.25 D.	
S.D.	±1.22 D.		±0.29 D.	

TABLE III
BASELINE DATA

patient		original k's	suggested B.C. (from F.G.)	ordered B.C.
17 eyes, before fitting with Hydro-Marc™ toric lens				
J.N.	OD	44.37/43.12 @ 81	8.83	8.30
	OS	44.00/42.50 @ 72	8.94	8.30
M.H.	OD	40.75/45.87 @ 82	8.95	9.20
	OS	40.12/45.75 @ 100	9.05	9.20
W.C.	OD	41.87/44.37 @ 90	8.90	8.45
	OS	41.50/43.87 @ 104	9.00	8.45
G.R.	OD	43.00/46.25 @ 92	8.67	9.05
	OS	43.00/46.25 @ 88	8.67	9.05
J.P.	OD	N/A	N/A	N/A
	OS	43.62/42.50 @ 71	8.95	8.45
C.Mc.	OD	41.12/43.87 @ 80	9.05	9.05
	OS	40.25/43.75 @ 90	9.13	9.05
L.P.	OD	43.00/44.50 @ 90	8.85	9.05
	OS	43.25/44.50 @ 90	8.80	9.05
M.E.	OD	41.50/44.25 @ 97	8.95	9.05
	OS	41.50/45.00 @ 94	8.90	9.05
D.R.	OD	45.12/43.25 @ 118	8.80	9.05
	OS	45.25/43.87 @ 68	8.70	9.20
7 eyes, before fitting with Hydrocurve II™ toric lens				
M.M.	OD	42.75/44.75 @ 90	8.75	8.60
	OS	43.00/45.00 @ 90	8.74	8.60
J.I.	OD	44.62/47.12 @ 90	8.42	8.60
	OS	44.00/46.00 @ 95	8.56	8.60
M.R.	OD	43.50/46.25 @ 94	8.58	8.60
	OS	43.50/46.25 @ 94	8.58	8.60
D.G.	OD	44.25/43.62 @ 107	8.74	8.60
	OS	N/A	N/A	N/A

fitting guide and lenses ordered from the appropriate lab. The lenses were evaluated after dispensing and patient adaptation.

After selecting the initial trial lens from the appropriate diagnostic set, the lens was placed on the cornea and allowed to remain on the eye for at least 30 minutes to allow for initial adaptation and equilibration. After this initial adaptation, period was over, the cornea-lens relationship, comfort, acuity, and over-refraction were evaluated, using the "ROMAC" criteria, which are:

RETINOSCOPIC REFLEX--the reflex should appear sharp, crisp, and without distortion--as it would without the lens on the eye. If any splitting or splaying is observed, another trial lens may be indicated.

OVER-REFRACTION--Once a good-fitting lens has been determined on the basis of the procedures outlined, spherical and sphero-cylinder over-refraction should be done to determine the power of the lens to order. A stable end-point with good acuity is desirable.

MOVEMENT--A good-fitting lens will result in one-half to one millimeter of vertical movement on blinking and should recenter immediately. This is best evaluated with the slit-lamp using a horizontal slit in close proximity to the lower portion of the lens. This slit is used as a reference point to judge the amount of vertical movement. Also, the amount and direction of lens rotation is evaluated to help determine the axis orientation in the final ordered lens.

ACUITY--Visual acuities taken through the over-refraction lens must be adequate and stable. If vision is clear after a blink, then blurs, the lens may be too steep; if the acuity through the lens is initially distorted after the blink, then clears, the lens may be too flat.

CENTERING--The lenses should first be observed with the eyes in primary position with and without the lids retracted, to make sure the lenses do not lag excessively laterally or vertically. A good lens

> will be found to lag only one or two millimeters on upward gaze. The lens should also be observed on lateral gaze to determine whether there is excessive decentration. Eyelids should then be retracted and the lens decentered manually about 3/4 of the way off the cornea to determine recentering capabilities of the lens, which is indicative of whether the lens may be too steep or flat. An optimum or loose-fitting lens will usually spring back to a centered position immediately, while a steep lens will lag a moment before recentering.

An additional criterion for evaluating lens fit was that of keratometer mire evaluation. This was done with the lenses in place. Regularity and variability of the mire images were noted. A proper cornea-lens relationship will result in mire images which are clear and free from distortion before and after a blink. If the mire images are first clear, but become blurred, a base curve that is too steep may be indicated; if the mires are initially distorted, but clear after a blink, a too-flat lens may be indicated.

DISPENSING

Before lenses were dispensed to a patient, they were inspected for clarity and verified for sphere power, cylinder power, and axis, using the Nikon projection lensometer. Axis was determined by placing the lens in the position showing most base-down prism, as indicated by mire displacement, and verifying as usual. (This method was described to the researchers by Dr. Courtwright, O.D., consultant to Frontier Contact Lens, of Jacksonville, Florida, manufacturers of Hydro-Marc lenses.)

The patient was then instructed in care, hygiene, and use of the lenses. All patients were asked to use Boil 'n' Soak™ and Preflex™, with heat, to reduce the possibility of allergic

reactions. They were then asked to adhere to a wearing schedule, which consisted of an initial four hours per day, building up to eight hours per day at the rate of one added hour each day. At this point, follow-up examinations were held, after which, if no problems were observed, the patient was encouraged to build up to full-time wear. Follow-up examinations were made up of evaluations of the "ROMAC" criteria already described, plus keratometer mire evaluation and any other procedure deemed necessary.

CRITERIA FOR SUCCESS

Subjectively, the patient should have full-time wear of twelve hours or more, no subjective complaints, comfortable vision with the lenses, and normal cosmetic appearance. Also, the manifest visual acuity should be within one line of that previously attained with spectacles or hard contact lenses.

Objectively, there should be minimal peri-limbal injection, minimal corneal edema or other corneal insult, and minimal changes in central keratometer readings.

RESULTS

A total of thirteen patients participated in this study. Two patients had only one astigmatic eye each (the other was fit with a spherical lens in each case), for a total of 24 eyes. Of these, seven were fit with Hydrocurve II toric lenses, and seventeen with Hydro-Marc toric lenses.

With the group of Hydrocurve II patients, seven lenses were ordered and all seven of these were considered successful fits, by the criteria previously established. In the Hydro-Marc

group, 31 lenses were received, of which three were successful. (See Table IV for more detailed information.) A total of 37 Hydro-Marc lenses were ordered, with six lenses not delivered by the time the study ended.

The success rate for the Hydrocurve II toric lens, based on the number of lenses ordered, was 100%. This contrasts markedly with that of the Hydro-Marc, which was 9.7%, or 17.6% when based on the number of patients that were successfully fit within the sample.

In a small group of patients such as the one studied here, these percentages may or may not be significant. However, the fact remains that all but one of the Hydro-Marc patients required more than one order and that some were still not successful after three tries. (See Table VII)

DISCUSSION

Why was there such a large difference in the ability to gain successful fits between these two toric lenses? We will attempt to answer this question by first addressing some of the difficulties encountered with the Hydro-Marc toric lens.

One of the main problems of this lens was that of variability in fit between lenses received and those used in diagnostic fitting. 58.1% of Hydro-Marc lenses received did not fit comparably to the diagnostic lens; that is, they fit either flatter or steeper than expected, to the point of being uncomfortable and/or unwearable.

TABLE IV

DATA FOR SUCCESSFUL FITS

patient	eye	Sbj. Refr. (7a)	VA thru S.R.	BC sugg from F.G.	BC/diam	final Rx power & axis*	final VA
Hydro-Marc™: 9.7% considered successful (criteria satisfied)							
L.P.	OS	-2.00-1.25 x 180	$20/15_{+1}$	8.80	9.05/14.50	-1.00-1.25 x 008	$20/15^{-2}$
M.E.	OD	+o.50-3.25 x 180	$20/20^{+1}$	8.95	9.05/14.0	+0.25-3.50 x 170	$20/25^{+2}$
	OS	plano-3.50 x 007	20/15	8.90	9.05/14.0	plano-2.75 x 020	$20/20^{+}$
Hydrocurve II™: 100% considered successful (criteria satisfied)							
M.M.	OD	-2.75-1.50 x 180	20/15	8.75	8.60/13.50**	-2.75-1.25 x 180	20/15
	OS	-2.50-1.25 x 180	$20/15_{-1}$	8.75	8.60/13.50	-3.00-1.25 x 180	$20/15^{+2}$
M.R.	OD	-3.50-1.50 x 010	$20/20^{-2}$	8.40	8.60/13.50	-3.75-1.25 x 010	$20/20^{-2}$
	OS	-4.75-1.50 x 180	$20/20^{-2}$	8.60	8.60/13.50	-4.50-1.25 x 180	$20/15^{-}$
J.I.	OD	-3.00-1.00 x 180	20/20	8.60	8.60/13.50	-3.12-1.12 x 180	20/15
	OS	-3.00-0.75 x 180	20/20	8.60	8.60/13.50	-2.87-1.37 x 180	20/15
D.G.	OD	-1.75-1.25 x 100	20/20	8.75	8.60/13.50	-1.50-1.25 x 100	20/20

*axis was corrected for rotation on the eye

**8.60/13.50 being the only base curve and diameter available at this time from Hydrocurve II (see Table I)

This experience is probably due in part to the practical difficulty in verifying the base curves of these back-surface toric lenses. Attempts to do so were made by two different methods which have been shown to be at least moderately effective on spherical soft lenses.* The first of these was done with a modified Bausch & Lombe Keratometer, to which a wet cell had been attached, resting above a 45-degree tilted mirror. The second method involved the use of the Soft Lens Analyser™, by Hydrovue, which is essentially a shadowscope, through which lens cross-sections are seen as compared to known templates. It proved to be nearly impossible to verify the base curves of these toric lenses using either of these two methods.

This lack of a good, reliable method for toric soft lens base curve verification left us in the position of taking the lab's word in the matter. However, information was available for assessing base curve reliability. This was accomplished by observing and recording how successive lenses compared in fitting characteristics with diagnostic lenses. For example, in the case of L.P., lenses were ordered based on diagnostic evaluations which, when received, were fitting excessively flat. These were returned to Frontier Contact Lens for re-verification and consultation with Dr. Courtwright; these lenses were confirmed to be one to two steps flatter than ordered. A second example was in the case of patient W.C. The first pair of lenses ordered was judged to be

*Johansen, C.P., "A Procedure for Hydrogel Contact Lens Verification." unpublished Senior Thesis, Pac. Univ. College of Optometry, March, 1977.

too tight (tighter than the fit of the diagnostic lens used), and a second pair was ordered one step flatter. This second pair provided an optimum fit with proper movement and centering, but the power and axis were not appropriate. The third pair, reordered with the same base curve and diameter as the second, were once again fitting too tightly.

According to Frontier's Dr. Courtwright, the lens should be manufactured such that the base curve is an average of the two curves on the back surface of the lens; a spherical diagnostic lens should give a reasonable representation of the way the final lens will fit. Either there are problems with base curve verification, or the problem is in quality control.

There was a large amount of variability in other parameters of the Hydro-Marc lens as provided by Frontier, also. Sphere power errors greater than $\pm$ 0.50 D. occurred in 19.4% of lenses received, cylinder power errors of the same magnitude were found in 16.1%, and cylinder axis errors greater than $\pm$ 5 degrees were present in 66.7% of lenses received. Miscellaneous errors (as in one lens received without prism ballast) accounted for another 9.7% of errors in fabrication. Of the lenses received, 48.4% had combinations of two or more of the above errors; table V has more detailed information.

Other difficulties in prescribing Hydro-Marc lenses were encountered in the form of communication failures between Pacific University's Forest Grove Optometry Clinic where the study was

TABLE V
UNSUCCESSFUL FIT ANALYSIS

Hydro-Marc™: 90.3% unsuccessful (criteria not satisfied)

Poor Fit: 58.1%

Too Steep: 22.6%
Too Flat: 35.5%

(when compared to diagnostic lens fit)

Power Errors (greater than ± 0.50 D.)

Sphere: 19.4%
Mean: -0.27 D.
Range: +0.37 to -1.25 D.
S.D.: ± 0.41 D.

Cylinder: 16.1%
Mean: -0.02 D.
Range: +1.25 to -1.25 D.
S.D.: ± 0.51 D.

Misc. Error*

9.68%

Cylinder Axis Error (greater than ± 5 deg.)

Total: 66.7%
Mean: 14.4 deg.
Range: 2 to 48 deg.
S.D.: ± 12.8 deg.

Combination of Errors

2 or more: 48.4%
3 or more: 19.4%
4 or more: 6.5%

Hydrocurve II™: 0% unsuccessful (criteria not satisfied)

*miscellaneous error includes those lenses with edge flaws, no prism ballast, etc.

all percentages are of total lenses received

done, the Hydro-Marc dealer, Opti-Con, in Portland, Oregon, and the manufacturer, Frontier Contact Lens, of Jacksonville, Florida. These difficulties were somewhat alleviated by establishing a system of ordering direct from Forest Grove to Frontier by telephone; this resulted in an average of one month faster delivery time. Table VI summarizes delivery times of both types of lenses.

Those Hydro-Marc lenses which were successful were so because the lens received fit comparably to the diagnostic lens, and had parameters that verified closely with what had been ordered. One successful fit which could not be explained in this manner was in the case of L.P., since the sphere power verified at 1.00 Diopter more plus than in the spectacle refraction.

In the cases where the Hydrocurve II toric lenses were prescribed, the high level of success can be attributed to two factors. The first is the use of good diagnostic trial fitting procedures, using lenses with the cylinder already in place. This gives a better opportunity for assessment of rotational effects, physical fit, and astigmatic correction; the diagnostic lens more closely resembled the final lens. The second factor is that the verified parameters of the HC II lenses received were in good agreement with those ordered.

There were no problems encountered in dealing with the lab, and delivery time for most of the HC II lenses was less than one month.

The main limitation of the Hydrocurve II torics was the limited range of parameters available. Only 29% of our patients

TABLE VI
DELIVERY TIME (DAYS PER ORDER)*

Hydro-Marc Toric™	Hydrocurve II Toric™
ordered through Opti-Con:	ordered direct from lab:
Mean: 72.3	Mean: 23.0
Range: 31 to 111	Range: 12 to 39
S.D.: ± 27.8	S.D.: ± 11.75
ordered through Frontier:	
Mean: 41.3	
Range: 6 to 80	
S.D.: ± 29.1	

*time of delivery is defined as the amount of time each order took to be processed and returned to the Forest Grove Clinic by the appropriate lab

TABLE VII
NUMBER OF LENSES ORDERED PER EYE

Hydro-Marc Toric™	Hydrocurve II Toric™
Mean: 2.18	Mean: 1.0
Range: 1 to 3	Range: 1.0
S.D.: ± 0.73	S.D.: 0

could be fit with these lenses. It should be noted that the range of sphere and cylinder powers and axes in HC II is steadily increasing, and may eventually cover most patient needs. However, at this time there is still only one base curve (8.6 mm) and one diameter (13.5 mm) available in these lenses.

Among the fitting information gained in this study is an observation that those patients with against-the-rule corneal cylinder seemed to need a considerably steeper base curve than that indicated as a starting point by the fitting guides. Further study is needed to determine if this is an actual trend or an artifact; it does, however, point up the importance of using diagnostic lenses before ordering.

In all successful cases except one, the patients complained of poorer acuity and stress at the nearpoint. This is probably due to rotation of the lenses with normal near convergence; the lids could sometimes be observed with the biomicroscope to be holding the lens, thus preventing it from maintaining in proper position on the cornea. A possible solution to this may be the use of plus in spectacle form for near work; this suggested itself after several patients reported that bringing the reading material closer, thus providing some distance magnification, seemed to help. Perhaps the magnification effects of plus lenses would compensate somewhat for this. In any case, patients who are prospective candidates for these lenses should be forewarned about possible problems associated with extensive near work.

At first glance, the Hydro-Marc lens appears to be better suited to most patients' needs when considering the range of parameters available. However, due to the problems encountered in delivery time, reliability in the fabrication of the lens, and variability in fit between ordered lenses and those used in diagnostic fitting, the chances for achieving successful fits do not appear to be good at this time.

Given that the patient approximates those parameters available, we found the Hydrocurve II toric lenses to have a high level of success.

Much more clinical study will be needed, especially in the area of base curve verification, before the use of toric soft lenses will become commonplace. We hope information gained in this study will be useful in the future.

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